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REPRODUCE INSTRUMENTATION FOR PROJECT 6.2 OPERATION PLUMBBOB

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J. C. Hoadley

1 May 1961

DIAMOND ORDNANCE FUZE LABORATORIES
ORDNANCE CORPS ● DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C.

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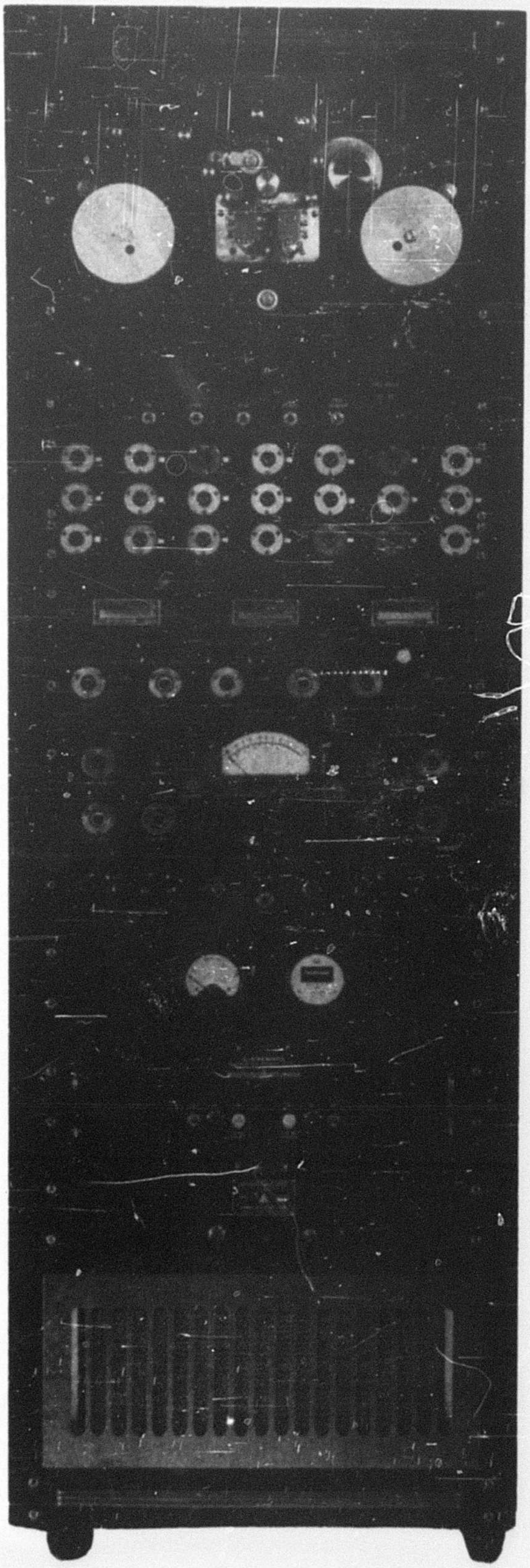

Frontispiece--Magnetic tape reproduce system.

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ABSTRACT

Instrumentation has been developed for the reproduction of magnetic tape data recorded on Project 6.2 Operation Plumbbob, both for rapid field data readout and subsequent laboratory data analysis. Signals can be read out within ±1 db over a frequency range from several cps to over 200 kc, with excellent fidelity. Previously available equipment was limited to a bandwidth of less than 100 kc.

1. INTRODUCTION

In the fall of 1956, DOFL initiated work--authorized by Armed Forces Special Weapons Project (now Defense Atomic Support Agency)--to measure the magnetic components of the electromagnetic field associated with a nuclear detonation. A magnetic tape recording system designed for this study is described in reference 1.

In order to read out data taken with this recorder, it was necessary to provide a magnetic tape reproduce system. Immediate field readout and analysis were imperative, since adjustment of the record system input attenuators could not initially be made with even reasonable accuracy because of the dearth of data on the magnitude of the fields being measured. Hence, input attenuator settings for successive shots depended on analysis of previous shot data.

Since no instrumentation was available covering the necessary bandwidth, DOFL undertook the development of the required seven-channel reproduce system, which would extend the bandwidth of the best available equipment by more than a factor of 2.

2. GENERAL SYSTEM REQUIREMENTS & DEVELOPMENT SCHEDULE

The Plumbbob tape reproduce system included the following general requirements.

(a) Overall bandpass characteristics adequate to reproduce data from several cps to over 200 kc in two channels of electronics--one with provision for demodulating FM/FM data from 2 cps to 2500 cps; the other a straight analog AM channel with response extending from 1000 cps to over 200 kc.

(b) Speed constancy, flutter, and wow characteristics superior to those of the Plumbbob recorder by at least an order of magnitude.

(c) Provision for extreme tape-handling care.

(d) Very consistent reproduce results.

(e) Minimum number of virtually foolproof interlocked controls.

(f) Fail-safe operation.

(g) Freedom from large magnetic fields.

(h) Provision for universal head mounting.

(i) Relay rack mounting.

The development of this system fell into the following concurrent phases:

(a) R&D of magnetic reproduce heads;

(b) Design of the transport mechanism; and

(c) Design and development of suitable electronics.

There was no instrumentation available with the capability of reproducing magnetically-recorded signals over the required bandwidth, nor was a contractor found who could develop the seven-channel reproduce system in the few months allotted. The system was, therefore, designed by DOFL and sufficiently developed (within the specified time) to satisfactorily reproduce data in the field. Following field phase tests of the Plumbbob program, an R&D program was instituted with the goal of refining the reproduce instrumentation for complete data reduction. The improved system, completed early in 1960 (frontispiece), is capable of accurately presenting all data for the Plumbbob Program as well as for the subsequent Hardtack Program.

3. DESCRIPTION OF SYSTEM DESIGN & OPERATION

3.1 Magnetic Reproduce Head

The reproduce head design was worked out jointly between DOFL and a contractor* who also supplied the Plumbbob-record heads described in reference 1.

Since the requirements were in advance of the state of the art at that time, the final unit required considerable research and development effort coordinated by DOFL and the contractor. The reproduce-head requirements were determined largely by the characteristics of the input signals and record system.

A well designed record head that is driven from a constant-current generator will subject the tape to a constant flux. Thus, data bandwidth considerations, aside from possible limitations in the constant current supply at very high frequencies, are largely a function of the reproduce head characteristics.

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*Heath Electronics

The magnetization retained by the tape is directly proportional to the signal current in the record head, whereas the signal voltage appearing at the output of the reproduce head (under ideal conditions) is proportional to the rate of change of flux caused by pulling the magnetized tape across the gap of the reproduce head. The reproduce head output voltage is the differential of the input signal from the lowest recorded frequency up to a frequency where head losses start to depress the 6 db/octave increase in output voltage.

The point where the slope equals zero is called the knee. Beyond the knee, output voltage falls rapidly to zero at the frequency where the head electrical gap width equals one wavelength (on the recording tape) of a (sinusoidal) recorded signal (average output = zero)

Although it would be desirable to place the knee of the output curve above the desired system bandpass, this was not possible at the present state of the art. The knee, in a typical reproduce head (figure 1), usually occurs well below one-half of the highest desired reproduced frequency. This requires the inclusion of post emphasis (increased gain at high frequencies) in the design of the reproduce amplifier to maintain a flat system response Post emphasizing the higher frequencies, however, increases the noise, which reduces the overall system dynamic range.

The electrical width* of the gap determines the useable high-frequency limit of the head. Smaller gaps are capable of resolving higher frequencies (at a given speed), but as the head bandwidth increases, its output voltage decreases. The head output voltage at the knee (25 kc or higher in a typical head at 60 ips) is no more than several millivolts. Therefore, since it is extremely difficult to maintain amplifier noise levels better than 20 db below this value (over a frequency range of several hundred kc), even a small reduction in head output voltage subtracts directly from the system dynamic range. The system dynamic range is measured from a specified peak recorded signal level (usually) containing 3 percent third-harmonic distortion to the total reproduced broadband noise in the absence of a signal.

The output voltage and wear life are opposing factors in a magnetic reproduce head design. Since the oxide coating on magnetic tape is thin (0.35 to 0.65 mil), the part of a magnetic head gap depth of greater than this amount might be regarded as a magnetic

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*The electrical width of the gap approaches the physical width as a limit. The change in incremental permeability of the core material at the pole faces due to disturbing its ordered character by cold working (lapping) results in a measured electrical gap greater than the physical one.

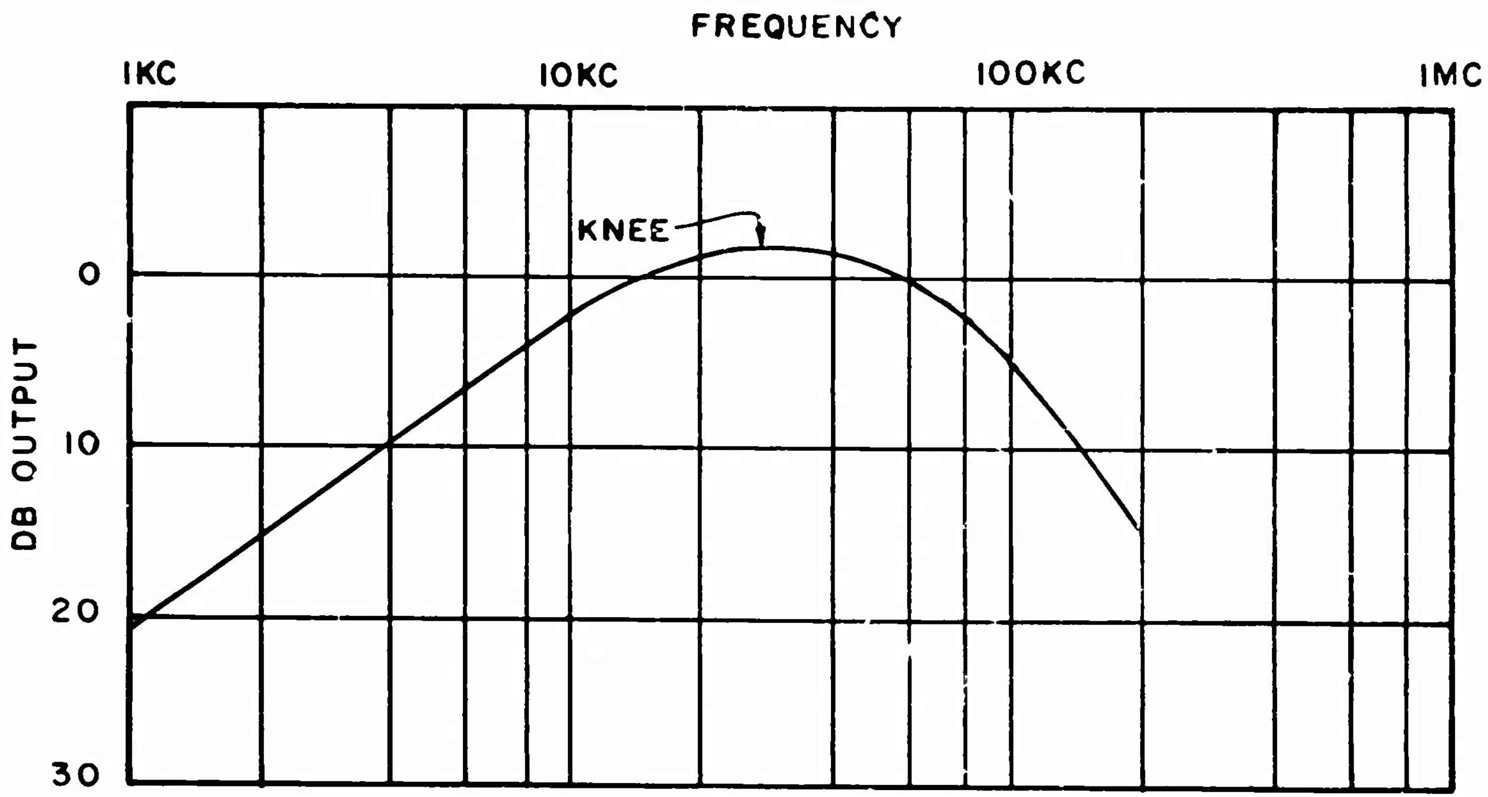

Figure 1. Response of reproduce head.

shunt which would reduce head output. In addition, the cross-section area of the gap influences the head coil inductance, which in turn affects the head resonant frequency and hence the high-frequency output voltage. A high resonant frequency, together with a high knee frequency and high output voltage requires a small gap depth, whereas long head wear life dictates a greater gap depth The gap depth of a typical head is 30 mil. By utilizing a harder head core material and a shallow gap depth, higher output may be provided. For example, alfenol has wear characteristics that exceed those of super-permalloy, etc by 8 to 10 times and has been used for heads where long life is of major importance as in motion picture magnetic stripping reproduce equipment (If the head were to be used in a one-time-missile application, as much as 10-db output voltage increase could be effected by providing a very small gap depth, allowing only for test wear and a single operational use.)

The designer, therefore, is faced with accepting gap geometry that is the best compromise between wear, bandwidth, and dynamic range. Reproduce head output voltage can be optimized by adjusting the inductance of the head coils subject to the requirement that the head not resonate within the bandpass. This would cause serious phase distortion in complex signals and also preclude multispeed operation.

3.2 Multichannel Reproduce Head

Multichannel heads have additional requirements such as gap scatter, cross talk, uniformity of frequency response, inductance, Q, null point, and gap and core losses. In addition to the mechanical limitations that are required to position the heads properly with respect to the tape, electrical stability must be maintained and isolation effected against external magnetic fields

Measurements were made on two final models of the seven-channel reproduce head shown in figure 2. The mechanical gap dimension in these heads was 0.00025 in. and the electrical gap was measured as 0.00028 in. Head inductance and Q were measured with GR-1650 A impedance bridge. (Voltage across the head was held to 5 mv at 1000 cps from the internal generator of the GR-1650A with full sensitivity.) Typical results are as follows:

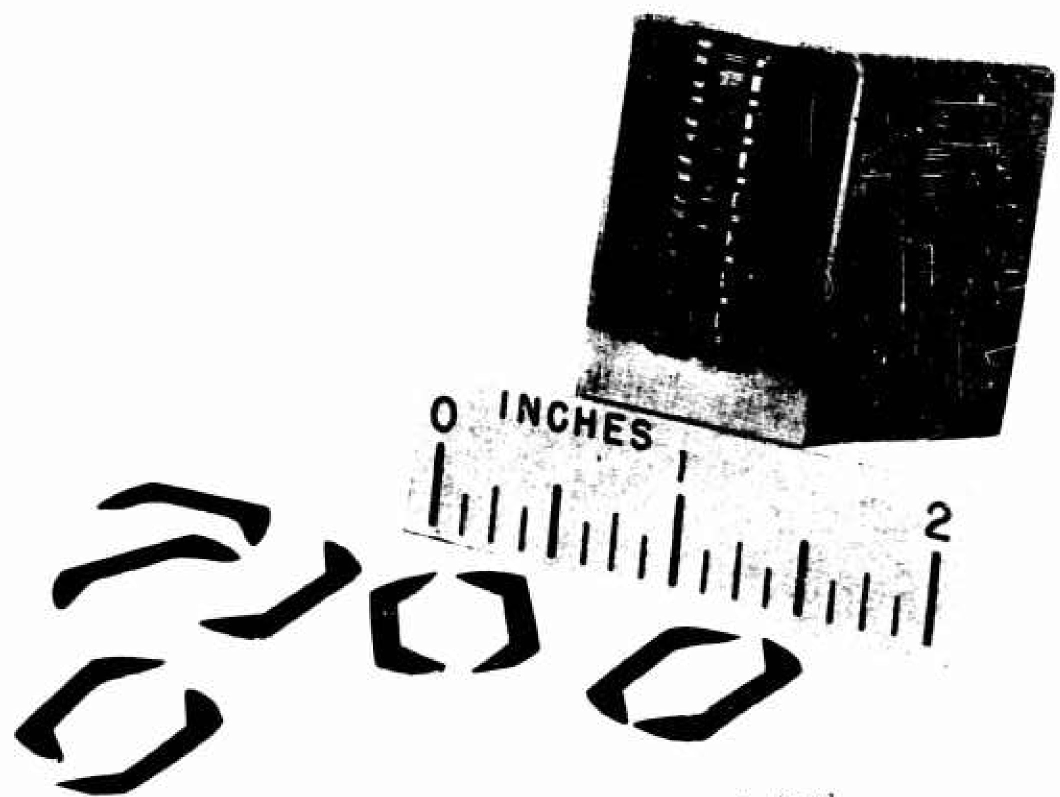

Figure 2. Seven-channel magnetic head.

Reproduce Head P-1			Reproduce Head P-2		
Channel*	Inductance (mh)	Q	Channel	Inductance (mh)	Q
1	1.40	0.86	1	1.21	0.77
2	1.34	0.82	2	1.11	0.72
3	1.42	0.87	3	1.04	0.67
4	1.35	0.82	4	1.04	0.68
5	1.32	0.82	5	1.14	0.73
6	1.13	0.71	6	1.05	0.67
7	1.38	0.84	7	1.22	0.78

*(Channels are numbered from outside to base)

The small spread of inductance and Q values from track-to-track in these heads resulted in a very consistent channel-to-channel maximum output variation of less than 1 db.

3.3 Reproduce Electronics

3.3.1 Design Objectives

The reproduce system was designed to accommodate playback of an AM and FM channel simultaneously. Because of the wide bandwidth of recorded information, it was necessary to combine the reproduce outputs of a low-frequency and a high-frequency channel on a dual-beam oscilloscope to present a complete picture of the original signal.

The low-frequency channels (tracks 1 and 7) required a reproduce amplifier including two subcarrier discriminators with linear deviation of ±40 percent at carrier frequencies of 58 and 17 kc. The actual recorded carriers were 116 and 34 kc, but playback was performed at half speed (60 ips), which was essential to reduce tape deterioration. This condition occurs very rapidly at 120 ips because of high temperature generated at the point of contact with the magnetic heads.

The high-frequency channel analog reproduce amplifier was designed to operate from the 1.5-mv output of head tracks 2, 3, 4, 5, and 6. An output potential of 1.0 v was produced with about 30 db S/N over the 500-cps to 100-kc range at 60 ips. This resulted in adequate reproduction of the 1000-cps to 200-kc data channels recorded at 120 ips.

3.3.2 Amplifiers

The reproduce amplifiers were developed for quick-look data readout for field use in Operation Plumbbob; they performed satisfactorily for this purpose. For laboratory use, a more refined amplifier, ITE 269-C, was developed.

Reproduce Amplifier (mod 2).--The mod 2 reproduce amplifier (fig. 3) consisted of three voltage-amplifier stages followed by a cathode follower. The input stage was designed to produce the lowest possible noise. The circuit is of the cascode type, utilizing a low-noise dual triode (12AY7). All components associated with this circuit (including capacitors and resistors) were chosen with low noise as a criterion. The input circuit was isolated from the reproduce head to preclude any d-c leakage, which could be caused by grid current in the input triode. This input stage was coupled to the following stage by an integrating network, designed to compensate for the fact that the magnetic head output is the differential of the signal flux on the tape.

The network is followed by a pentode voltage amplifier stage. The pentode was chosen because of its high-gain bandwidth capability and excellent linearity for small signal voltage swings. The gain of the stage was deliberately increased above the reproduce head knee by relieving the screen degeneration. This was accomplished by maintaining the screen at ground potential at frequencies above the point by C_{10}.

The pentode stage is followed by a low-μ triode (V3A) with a larger-than-usual portion of the signal appearing in the cathode circuit (across R_{16}). The degeneration, therefore, is relieved above the head-knee frequency by an adjustable LC circuit, which provides a steeper high-frequency rise than is possible with a capacitor only.

The cathode follower is next, which improves the amplifier-gain bandwidth by lightly loading the triode-amplifier stage, and utilizing a considerable length of coaxial cable at its output without attenuation of frequencies in the order of 100 kc.

The cascode and pentode amplifier stage heaters were powered from a well filtered d-c power supply; the plate potentials were supplied from a low-impedance, low-ripple, regulated power supply. The low-frequency response was deliberately "rolled off" below 100 cps in an effort to improve the noise figure as shown in figure 4. (It was believed that the AM low-frequency data would contain a high percentage of distortion, since the record bias optimization was slanted toward maximum high-frequency response.)

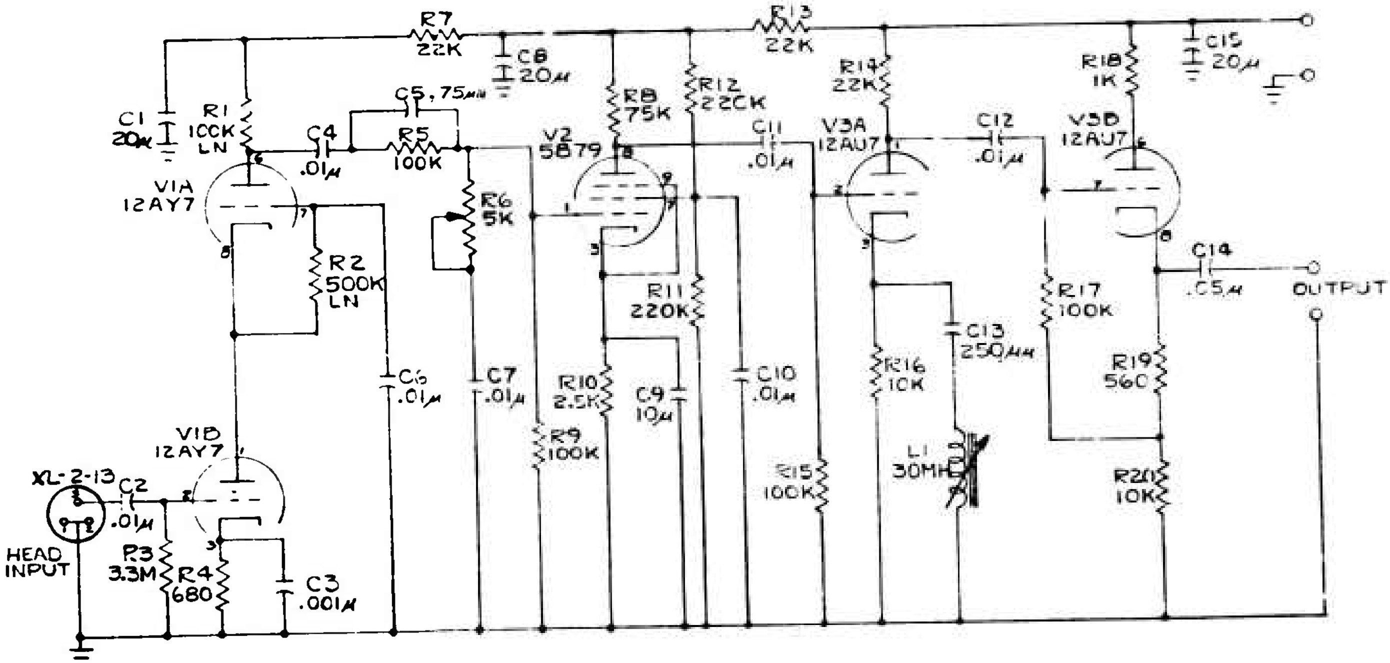

Figure 3. Schematic—reproduce amplifier model 2.

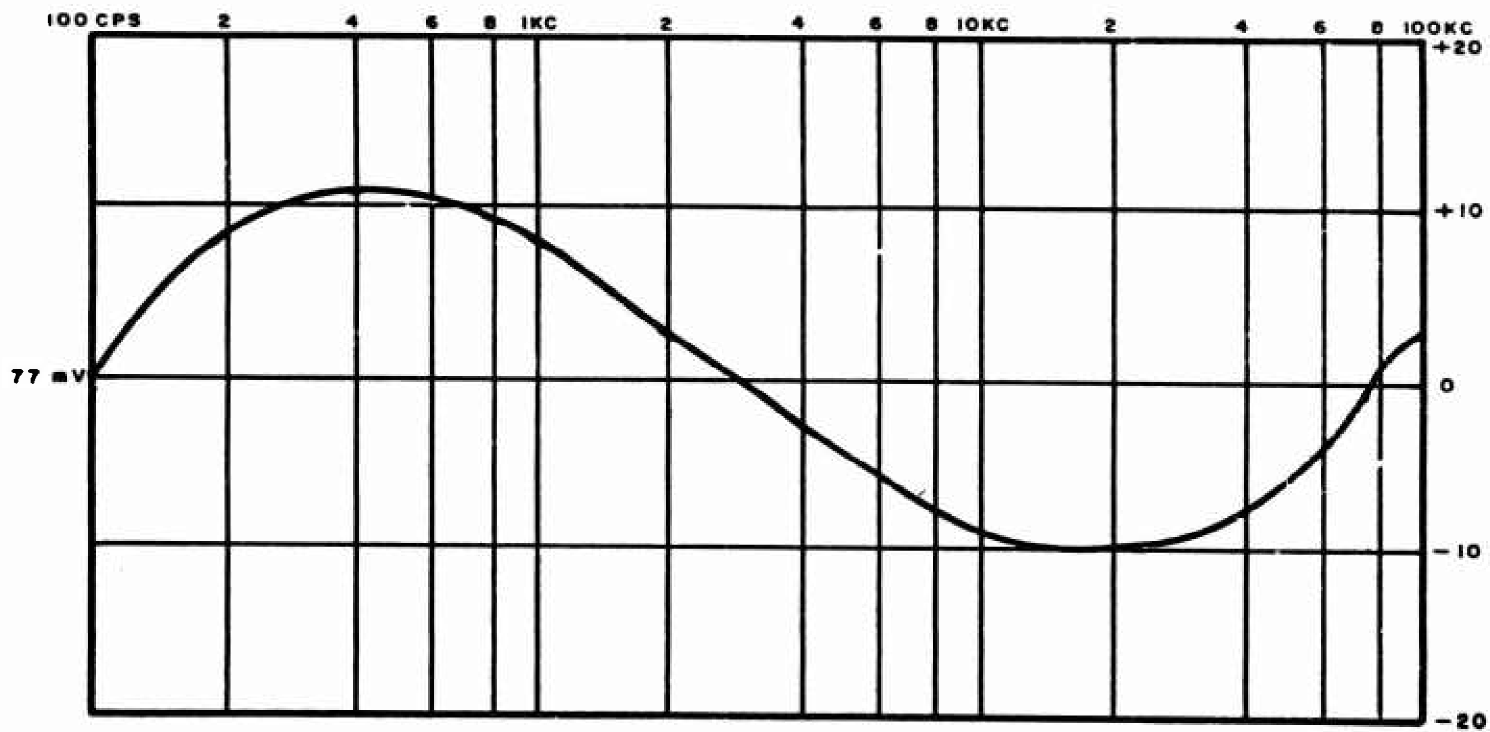

Figure 4. Frequency response, model 2 amplifier.

Although the system was intended for reproducing Plumbbob (and Hardtack) tapes, provision for record electronics was included. This provision permitted laboratory evaluation of future head and electronic designs. The various electronic units were arranged in plug-in modules, grouped functually on relay rack panels and mounted in a rack together with power supplies. This reproduce amplifier (mod 2) was used to read out data during the field phase of Operation Plumbbob.

Reproduce Amplifier (ITE-269-C).--Following field-phase completion, laboratory R&D effort was directed toward improved reproduction of the magnetic tape data previously taken. The main objective was the very faithful reproduction of the data, particularly since they represented new research information. Because the magnetic tape reproduce process results in the differential of the recorded signals, equalization must be introduced into the reproduce electronics. Unfortunately, phase linearity of the electronic system is disturbed in the process.

It became evident early in the program that a study should be made to correct the phase response (without disturbing the amplitude response) of magnetic tape reproduce systems. A contract* was therefore let to study the phase correction problem and to provide a design manual or handbook (ref 2) for use in designing phase correction systems. Simultaneously, DOFL investigated the problem from the standpoint of low phase distortion, reproduce-amplifier designs.

Phase distortion can be reduced by controlling the frequency response outside the amplifier passband by providing gaussian shaped roll off at both the high- and low-frequency extremes. Essentially, the amplifier then must have reasonably linear frequency response several octaves beyond each end of the useable bandpass. Because of the noise characteristics of the recorded tape, very low noise input circuits are unnecessary. Therefore, the ITE-269-C (fig. 5), developed at DOFL, utilized a pentode input stage that provided sufficiently low input noise and had high gain bandwidth. This allowed a wide-band magnetic head output signal to be built up to a point where noise was no longer a problem. The integrating network was placed in the plate circuit of the pentode stage. The pentode output circuit is not adversely loaded as a triode would be because of the varying load value of the RC integrating circuit. The pentode is followed by a cathode follower which, unlike a normal voltage-amplifier stage, does not appreciably load the previous plate circuit. This results in the integrating circuit being able to provide

*Rixon Electronics, Inc., Silver Spring, Md.

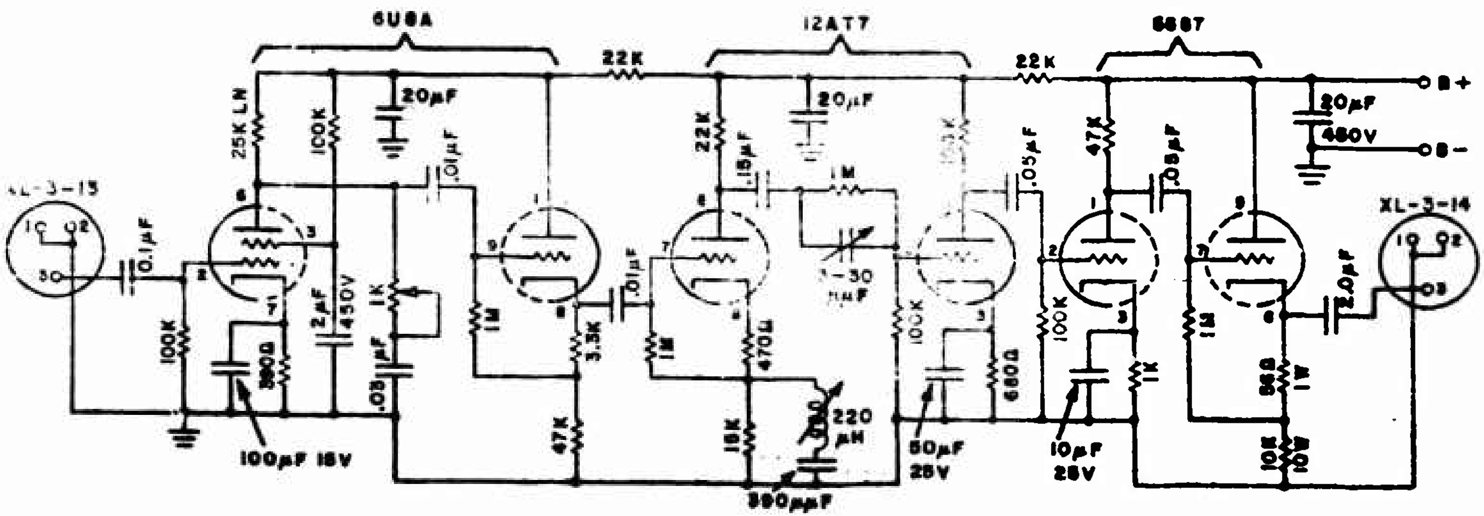

Figure 5. Schematic—response amplifier ITE-269-C.

a true 6-db/octave correction instead of the 5^+ db which is usually obtained. Following the cathode follower is a plate follower, which effects the post emphasis by a reactive network in the cathode circuit. This stage is coupled to a triode-voltage-amplifier stage through a reactive network, effecting additional high-frequency post emphasis. The output stage consists of a voltage amplifier and cathode follower, utilizing a 5687 tube capable of sufficient output power (low z) to drive a 75-ohm load (8 to 600-ohm circuits in parallel) with low distortion.

The ITE-269-C amplifier response curve shown in figure 6 is essentially the inverse of the reproduce head response, so that when the head is operated in conjunction with the amplifier, the combined response is flat to within ±1 db from 100 cps to 200 kc at a tape speed of 60 ips.

3.4 Tape Transport

3.4.1 Design Objectives

The design objectives included very low flutter (and wow), extreme ruggedness, and provision for careful tape handling. Specifically, the desired characteristics were:

(a) Tape speed at 60 ips and 120 ips

(b) Capability to use the special small reels used in the Plumbbob-Hardtack recorders.

(c) Acceleration of the tape without subjecting it to deformation forces.

(d) Very low tape skew.

(e) Extreme rigidity.

(f) Foolproof, interlocked controls.

(g) Fail-safe drive system.

(h) Very low friction.

The mechanical components of a tape transport must be maintained in accurate alignment with each other, which necessitates a very rigid mounting plate. The Plumbbob-Hardtack machines used a 3/8 in. front panel of dural die-plate 19 in. wide and 15-3/4 in. high, upon which was mounted a capstan drive assembly, takeup and supply reel turntable assemblies, a flutter capstan assembly, and a number of guides and torque arms.

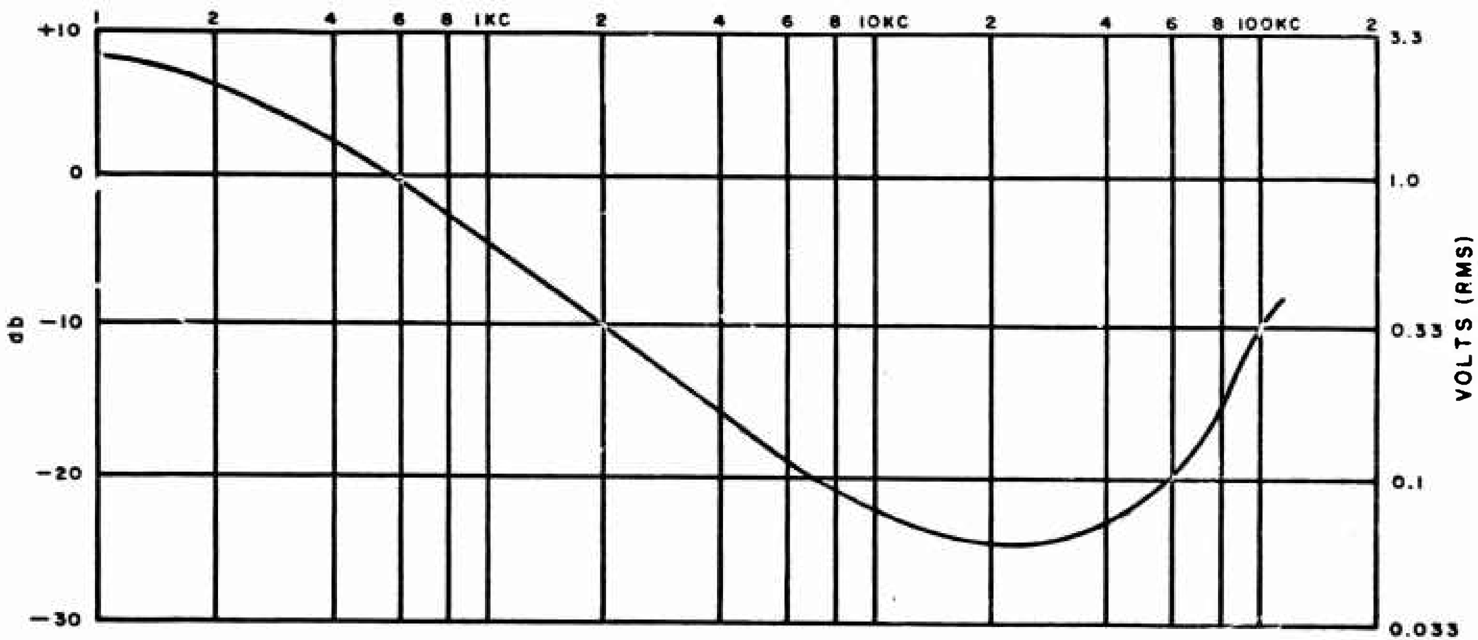

Figure 6. Frequency response, ITB-269-C amplifier.

The reel turntable assemblies included takeup and supply tensioning means, together with suitable forward and rewind provisions, and azimuthally adjustable magnetic head mounting plates in correct juxtaposition with the capstan drive.

3.4.2 Construction Layout

Top and rear views of the tape transport are shown in figures 7 and 8. The supply reel is on the left, capstan assembly near the center, and flutter capstan and takeup reel are on the right. The pushbutton controls are along the bottom edge of the transport plate.

Supply-Takeup System.--The supply and takeup turntable assemblies consisted of the torque motors used by Ampex Corporation in their 300-series recorders. These units were of excellent design and included solenoid-operated brake assemblies Use of a torque motor (rather than drag brakes) for the supply reel assembly results in a nearly constant tape tension, even though the diameter of the supply and takeup reels is constantly changing. The torque motors were energized with 60 cps ac which could cause serious flutter. Actually, the low measured flutter of the overall transport was attributed partially to the isolating action of the flutter-capstan assembly and the extreme care with which the torque motor units were built.

A torque motor has the advantage that its drag is easily adjustable by changing the resistance in series with the power source. Therefore, the supply and takeup tension can easily be adjusted for minimum flutter--consistent with intimate head-to-tape contact. Moreover, it is only necessary to short out the series ressistances for high-speed tape transport.

Ideally, the adjustment of the supply and takeup tension should be such that when the tape diameter is the same on both reels, the tape can travel over the capstan at the correct speed (60 or 120 ips) without the capstan driving it.

When the above conditions obtain (1) the capstan pinchwheel is engaged, (2) the capstan motor energized, then the capstan can accurately meter out the tape with minimum slip.

The variation in tension is then only a function of the changing reel hub diameter as the tape is transferred from the supply to the takeup reels.

Although the Plumbbob transport reel hub diameter ratio was 1-4 (empty-to-full), there was no problem from this source since the useful data occupied such a small portion of the tape.

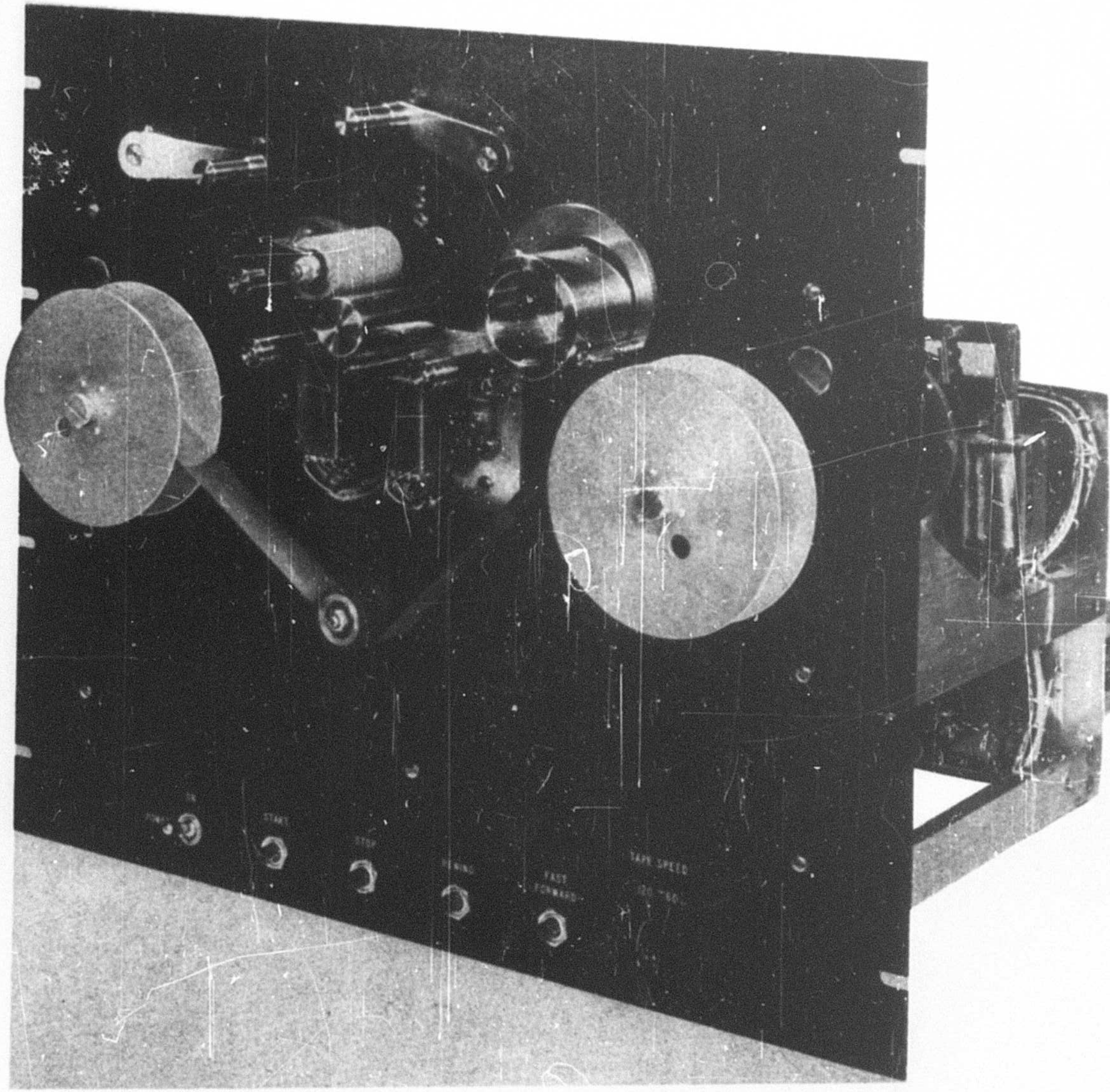

Figure 7. Tape transport, front view.

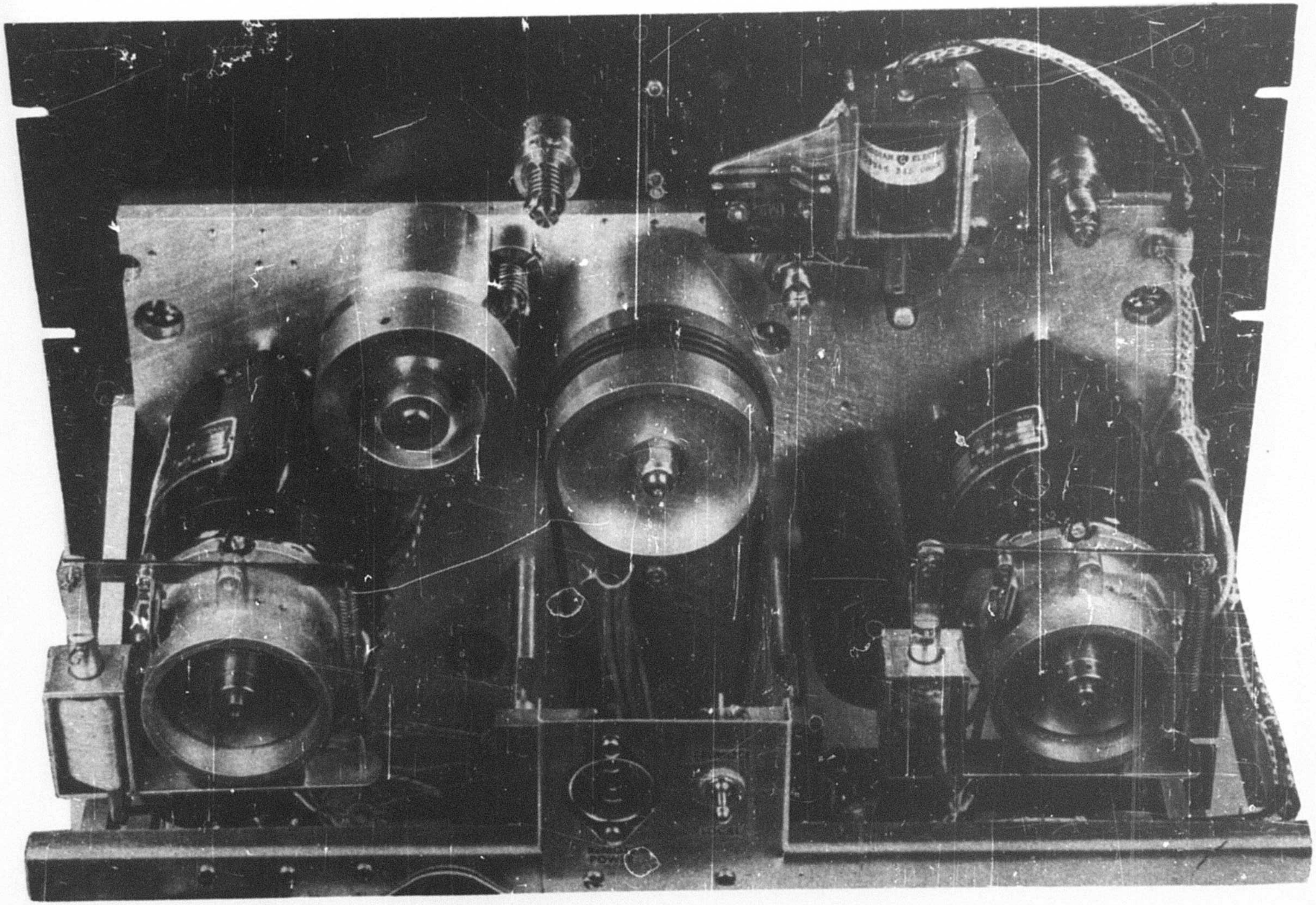

Figure 8. Tape transport, rear view.

Capstan Drive System.--This system consisted of a two-speed hysteresis synchronous motor, a multiple O-ring belt drive to an Fl wheel mounted in high-precision bearings, and a ground capstan. The capstan pinchwheel was mounted in a selected low-friction class 7 ball-bearing assembly on a pivoted arm which was activated by a dc-operated solenoid. Eccentricities (runout) in the rotating members that determine the forward velocity of the tape contribute directly to the magnitude of the flutter. Consequently, great pains were taken to minimize runout.

The motor pulley was ground with such precision that total runout did not exceed ±0.0001 in. The capstan pulley consisted of a heavy flywheel which, together with the flexible O-ring belts, constituted a low-pass filter that effectively prevented the 60-cps power pulses (in the drive motors) from reaching the capstan.

Three small-diameter O-rings were used instead of one large O-ring. The capstan shaft ran on selected class 7 ball-bearing assemblies mounted in the two ends of a solid brass block to preclude bearing-alignment problems. The capstan was precision ground in the tape contact area. Figure 7 shows the drive system.

The magnetic head mounting plate was positioned halfway between the reels and included two precision rolling guides at either end, together with a guide in the center to insure proper tape wrap around the gap area of the heads. The nonmagnetic No. 303 stainless steel guides were machined with shoulders for 1-in. tape. This provision accurately positioned the tape on the heads and precluded tape skew.

A flywheel and capstan, driven by the tape, were mounted between the head assembly and takeup reel. A tension arm was so mounted to wrap the tape around at least one-half the circumference of this flutter capstan. Since this capstan drove the heavy flywheel, it acted as a low-pass filter to isolate the tape (in the vicinity of the heads) from high-frequency variations in the tape-supply system.

Guide System.--Two movable guides and one fixed guide were provided between the supply reel and drive capstan. This guide system absorbed tape shock experienced when the pinchwheel clamped the tape as the machine started. Without the guide system, the tape would be accelerated almost instantly, causing severe strain on the tape (during subjection to the relatively large mass associated with the supply reel and its torque motor armature).

The time constant of the tension arms was adjusted to a speed fast enough to eliminate small variations in tape tension during normal operation.

Control Circuits.--On a chassis (located 12 in. behind and parallel to the transport front plate) were mounted the d-c relay power supply, fuses and tape tension adjustment controls, together with provision for a remote-control connection. The d-c relay power supply was extremely well filtered to preclude flutter, which could be caused by the vibration of the pinchwheel solenoid and consequent variations in pinchwheel pressure against the capstan.

All control pushbuttons were the momentary make (or break) type which actuated lock-in type relays. This effectively isolated the control circuits from variations introduced by the operator.

3.4.3 Operation (Play Mode)

With the power switch in the ON position, the following sequence of operation should be observed (fig. 9).

Start-and-Hold Functions.--When the play pushbutton is depressed, 24-v dc passes through: (1) terminal 6 of the Jones varrier strip, (2) the normally closed contacts 5 and 6 of relay K6, (3) the normally closed contacts 5 and 6 of relay K4, and (4) to terminal 13 and contact 1 of relay K2. Terminal 13 is one side of the relay K2 coil, and since the other side of the coil (terminal 14) is connected to the 24-v dc, the common relay K2 is energized. When relay K2 is energized, contacts 1 and 2 are made, providing a hold-in path until the stop button is depressed; at this time relay K2 returns to normal. Note that the coil of relay K1 is connected in parallel with the coil of K2. The capstan motor receives power through contacts 4 and 5 of relay K2.

Rewind Lockout.--When the play mode is in operation (relays K1 and K2 operated), provision is made to prevent the accidental operation of any other mode--rewind or fast forward. Rewind lockout is accomplished through contacts 2 and 3 of K1. When K1 is operated, contacts 2 and 3 are open, thus opening the control path of the rewind relays (K3 and K4).

Fast Forward Lockout.--This operation is accomplished through contacts 5 and 6 of relay K1. When K1 is operated, contacts 5 and 6 are open, thus opening the control path of the fast forward relays K5 and K6.

Capstan Solenoid.--The capstan solenoid requires 115-v dc and receives power through contacts 10 and 11 of relay K1 when relay K1 is energized. A capacitor (0.1 μf) across contacts 10 and 11 suppresses arcing across the contacts when the relays open.

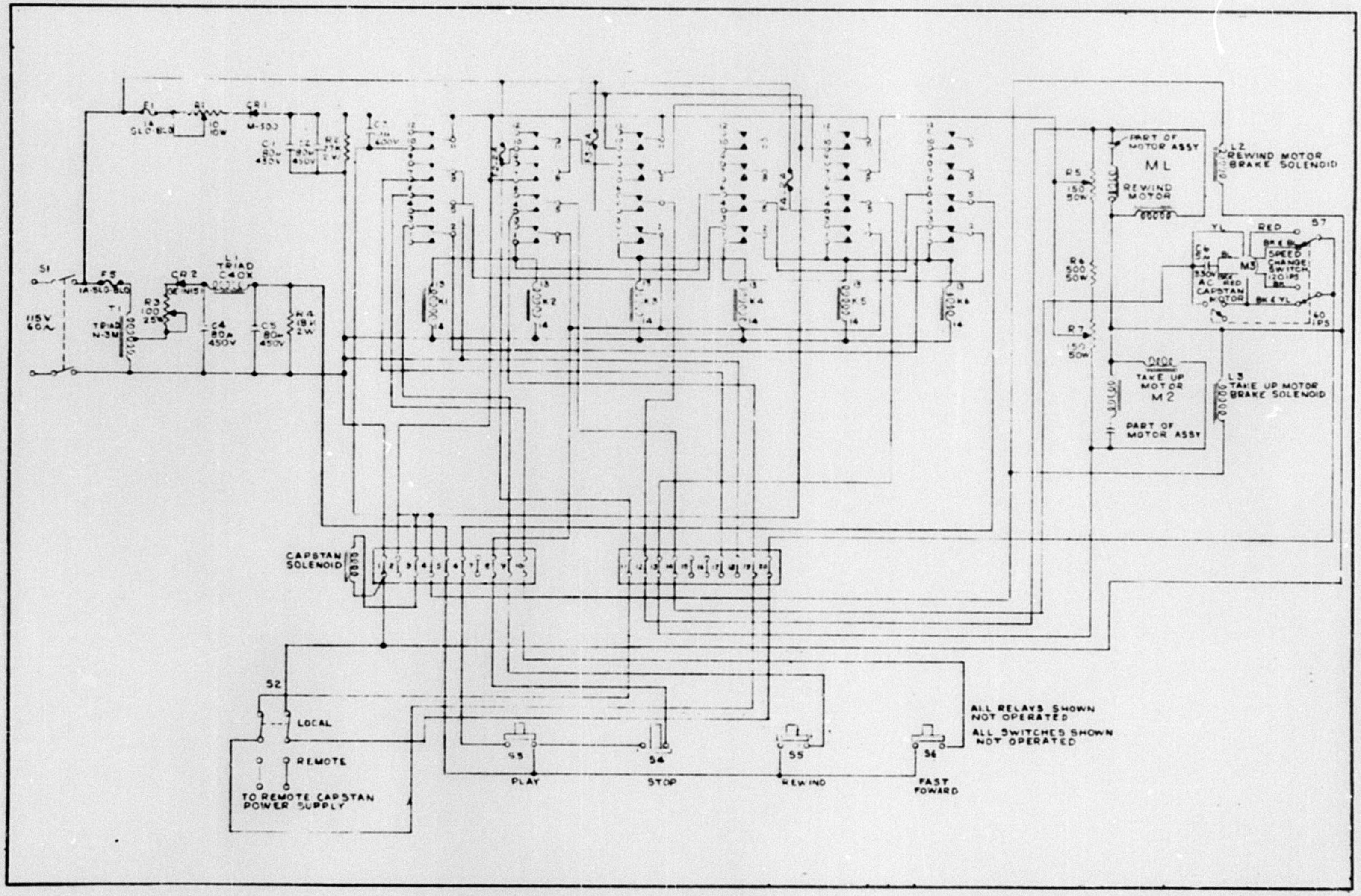

Figure 9. Schematic—tape transport.

Brakes.--The takeup and rewind motors are equipped with brakes that are operated by 115-v dc solenoids. The solenoids are energized when the brakes are off, resulting in fail-safe operation. For example, if power fails, the brakes are applied, bringing the tape to a halt instead of spilling it on the floor.

4. DATA REDUCTION

4.1 Field

Quick-look data reduction was accomplished in the field by observing the reproduced signals on a triggered sweep oscilloscope. The data represented a single nonrepetitive phenomenon, the interesting parts of which lasted about 10 μsec, making it necessary to photograph the reproduced signals.

The tapes were recorded at 120 ips and played back at 60 ips, with the original recording occupying a few msec (approx) of an overall 40-sec recording time (80 sec at 60 ips). It was, therefore, necessary to locate the approximate signal area by observation (and stopwatch); then rerun the tape while opening the camera shutter several seconds before the signal was expected. The oscilloscope was set for a single sweep and the sensitivity was adjusted to trigger from the signal. The signals were all observed to fall within ±3 sec from the center of the tape. Numerous spurious noise pulses, which bore a remarkable resemblance to the wanted signal, made it necessary to cross check the photographed results. Fortunately, the noise pulses were indigenous to a particular track. Therefore, it was only necessary to trigger the scope from what was thought to be a signal on one track and then look at the other tracks (on a given tape). If no signal was observed, then the photograph was that of a noise pulse. This data-analysis procedure was successfully used to properly adjust the recorder attenuators for each successive shot.

The above applies to the AM analog recorded channels only. Attempts to reproduce low-frequency channels failed, because of poor regulation in the field, and were not successfully reproduced until a year later.

4.2 Laboratory

Complete data analysis was subsequently accomplished over a period of several years, resulting in increased accuracy as improved readout instrumentation was developed.

The final instrumentation (fig. 10) utilized the DOFL ITE-269C reproduce amplifier and TEKTRONIX (mod 555) dual-beam oscilloscope. The traces from high- and low-frequency tracks were displayed simultaneously (usually at different sweep speeds) and photographed.

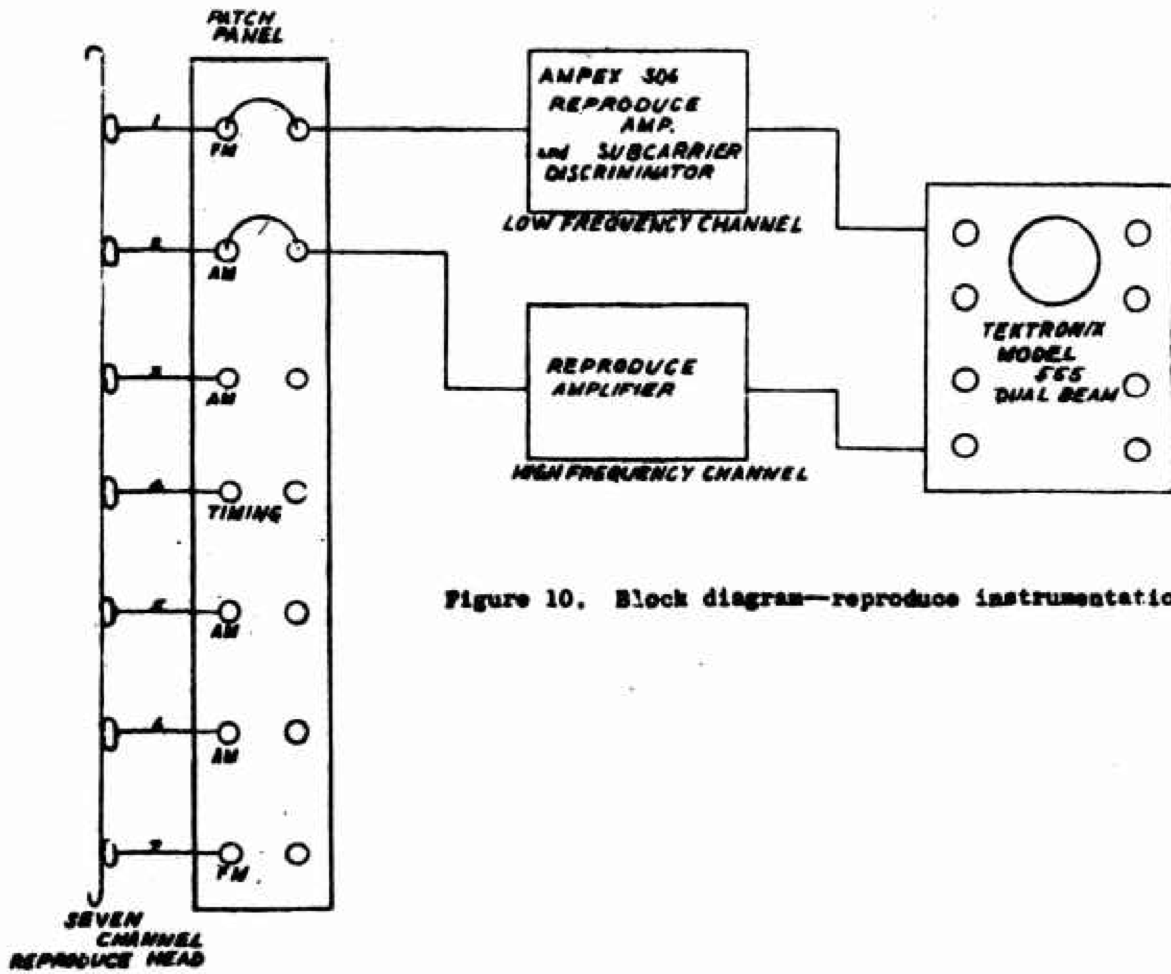

Figure 10. Block diagram—reproduce instrumentation.

The improved phase and frequency characteristics of the final instrumentation resulted in completely satisfactory data, even when the dual display involved waveforms that varied from hundreds of msec to a few μsec. Questionable noise pulses and other disturbances continued to occur on the data tapes. However, since noise pulses rarely occurred on all tracks simultaneously, the validity of a signal could be checked by triggering the scope from the data signal on another channel.

A novel method was used to display the data signals on the oscilloscope screen. This method allowed observation and measurement of the entire wave front, which is necessary when measuring recorded rise time, duration, and d-c level shifts. The tapes were played backward into a trigger circuit which, when activated by the steep rise on the beginning of the data waveform, generated a sharp pulse with a delay of a few μsec. This generated pulse was recorded on the tape-timing channel. When the tape was played forward, a large pre-data pulse occurred, which could be used to trigger the oscilloscope sweep, thereby displaying the data waveform in its entirety.

5. SUMMARY

A magnetic tape recording system (described in ref 1) was developed in connection with attempts made to measure magnetic components of the electromagnetic field associated with nuclear detonation. The instrumentation described herein is considered satisfactory for the reproduction of data taken with this recorder, specifically those data recorded on Project 6.2 Operation Plumbbob. (The system was also applicable for reproducing Hardtack tapes.)

Although the system requirements were in advance of the state of the art, a seven-channel reproduce system was designed and constructed with capabilities to:

(1) Reproduce magnetically-recorded signals over a frequency range from several cps to over 200 kc within ±1 db;

(2) Play back an AM and FM channel simultaneously;

(3) Obtain quick-look data reduction in the field; and

(4) Accomplish complete data analysis in the laboratory.

Despite questionable noise pulses and other disturbing factors on data tapes, appreciable accuracy of data reduction is attainable. Since noise factors seldom (if ever) intercept all tracks simultaneously, questionable signals may be checked through another track.

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TR-931, 1 May 1961, 14 pp text, 10 pp illus
OMS-5010.21.87801, DOFL Proj. 23300 - UNCLASSIFIED Report

Instrumentation has been developed for the reproduction of magnetic tape data recorded on Project 6.2 Operation Plumbbob, both for rapid field data readout and subsequent laboratory data analysis. Signals can be read out within ±1 db over a frequency range from several cps to over 200 kc, with excellent fidelity. Previously available equipment was limited to a bandwidth of less than 100 kc.

1. Magnetic tape data—Reproduce instrumentation
2. Magnetic tape reproduce amplifiers
3. Magnetic fields—Measurement instrumentation

I. Project 6.2, Operation Plumbbob
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